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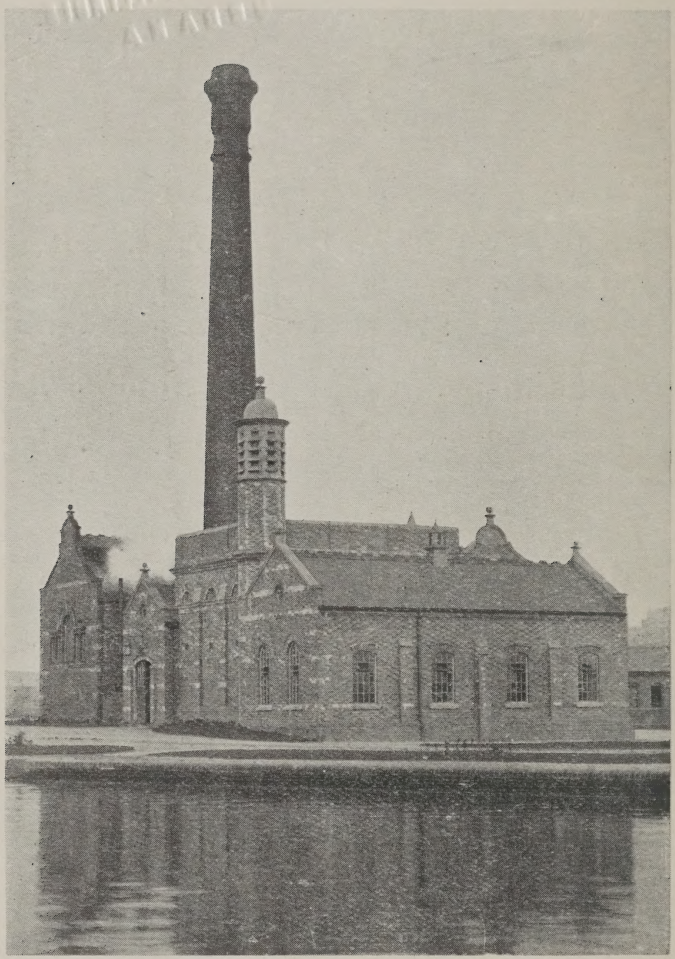
FOREWORD

THERE has been no attempt to give a complete description of the Board's Works in this booklet. My object has been to give a rapid survey of the sewage purification process, and of the works and plant employed to carry this out. To do this in such a way as to assist the memory of the visitor has been a primary consideration, hence the employment of so many pictures and diagrams to illustrate the text.

J. D. W.

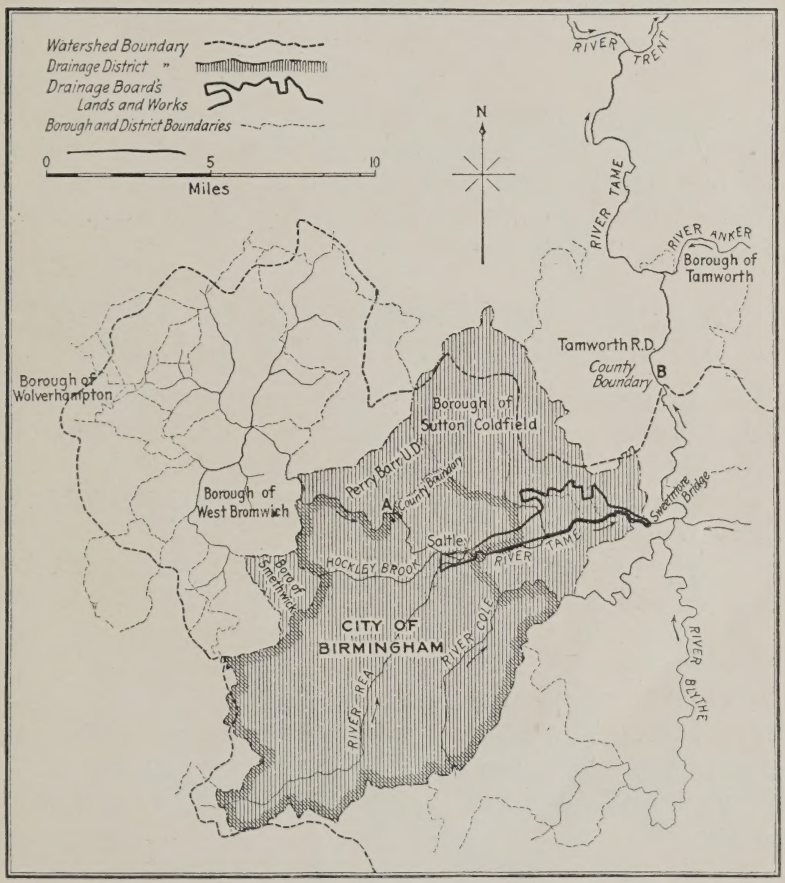
ENGINEER'S OFFICE,
JULY, 1923.



SLUDGE PUMPING STATION AT SALTLEY

THE WORKS OF THE BIRMINGHAM TAME AND REA DISTRICT DRAINAGE BOARD

THE Board, which was created in 1876, is responsible for a Main Sewerage District of 108 square miles, and the chief duties imposed on them by Statute are (1) to provide Intercepting Sewers, and (2) to treat the sewage conveyed to the Outfall Works before discharging it into the River.



MAP OF THE DRAINAGE DISTRICT

The Communities draining to the Board's Works are as follows :

City of Birmingham—	
Population as per Census of 1921	919,438
County Borough of Smethwick—	
Population as per Census of 1921	75,757
Royal Borough of Sutton Coldfield—	
Population as per Census of 1921	23,028
Urban District Council of Perry Barr—	
Population, as per Census of 1921	2701
Rural District Council of Meriden (part of)—	
Population, estimated	5,691
Total Population	1,026,615

To deal with sewage from this population the Board has three Works. The main one in the Tame Valley deals with a dry weather flow of 27,000,000 gallons per day, and the two Works in the Cole Valley deal with a dryweather flow of 3,000,000 gallons per day.

VOLUME AND CHARACTER OF SEWAGE DEALT WITH IN THE TAME VALLEY

The Intercepting Sewers which converge at the Board's Saltley Works are four in number, and they are capable of conveying more than 300,000,000 gallons per day.

The following is a typical sample of sewage arriving at the Saltley Works :

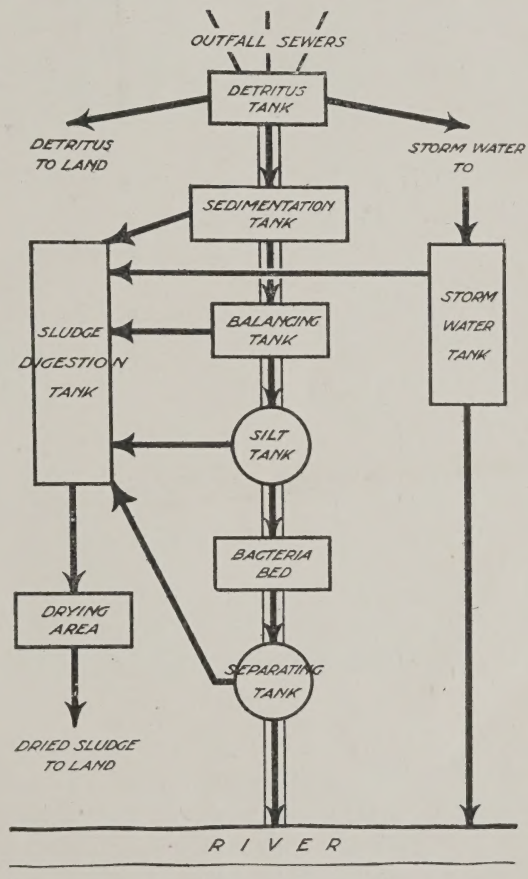
Oxygen absorbed in 4 hours	26.34	parts per	100,000
Free and Saline Ammonia ..	4.06	,,	,,
Albuminoid do. ..	1.52	,,	,,
Chlorine	18.90	,,	,,
Total Suspended Matter ..	57.70	,,	,,

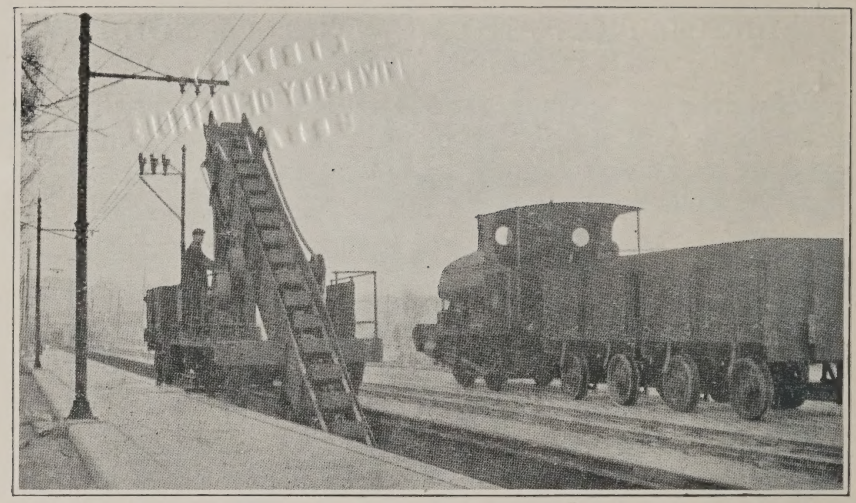
The Ministry of Health characterise sewage which has an oxygen absorbed figure of 7 to 8 parts per 100,000 as weak, average is given at 10 to 12, and strong as 17 to 25 parts per 100,000.

ELIMINATION AND DISPOSAL OF SOLIDS SUSPENSION (DETRITUS)

Before the sewage enters the Detritus Pit it passes through grids formed of bulb bars placed 7in. apart, which slope upwards in the direction of the flow at an angle of about 30° from the invert of the sewer.

DIAGRAM ILLUSTRATING THE METHOD OF PURIFYING BIRMINGHAM SEWAGE





The Detritus Pit is V shaped in section, 240 feet in length, 14 feet wide at the surface, and 19 feet deep. At the bottom it is just wide enough to allow the dredger buckets to move freely between the walls.

The above Illustration indicates the method of dredging and removal in trucks constructed for the purpose.

Only a small portion of the detritus is sold to farmers (less than 2,000 tons per annum) and this is chiefly from Ashold Tank. The bulk of it is buried or deposited on waste land.

Any detritus which is not arrested by this electrically operated Dredging Plant is washed into the first bays of the Sedimentation Tanks, whence it is removed with the finer silt called sludge.

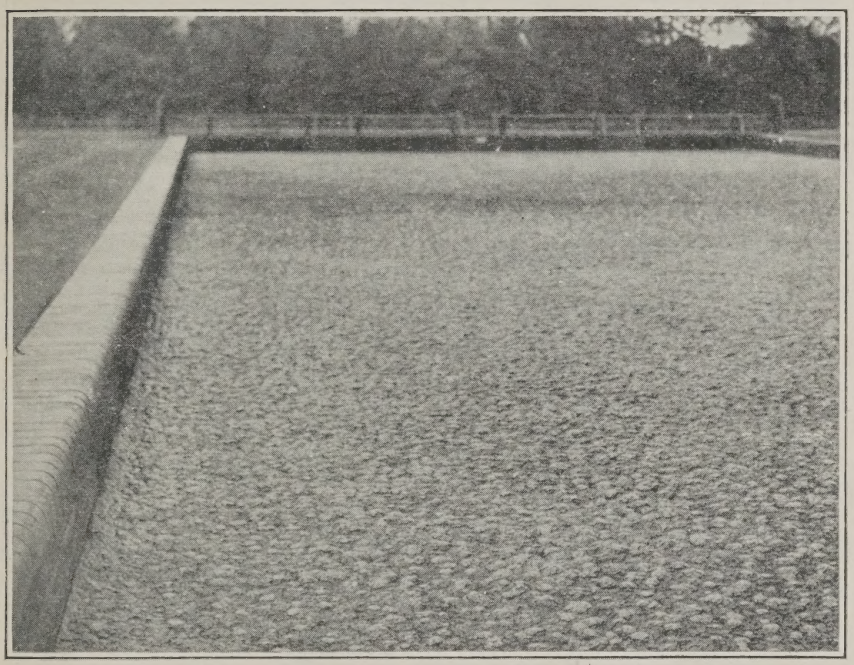
SEPARATION AND DISPOSAL OF SLUDGE

AFTER passing through the detritus pit the sewage flows through five sedimentation tanks, which have a combined capacity of 5,000,000 gallons. Here the grosser solids settle out and are removed every week by decanting the liquid, and pumping out the solids by means of steam driven, direct-acting sludge pumps.

The suction pipes are protected by grids which are kept free of rags and other substances that would, if allowed to remain, choke both suction pipes and pumps. The grids are kept in a workable state by electrically operated rakes.

The sludge is pumped into 50 digestion tanks which vary in capacity from 1,200 to 15,000 cubic yards.

The combined capacity of the digestion tanks, both at Saltley and Minworth, is 350,000 cubic yards. The annual amount of that output varies, but it may be stated at not less than 400,000 tons wet sludge, containing 10 per cent. of dry solid matter.



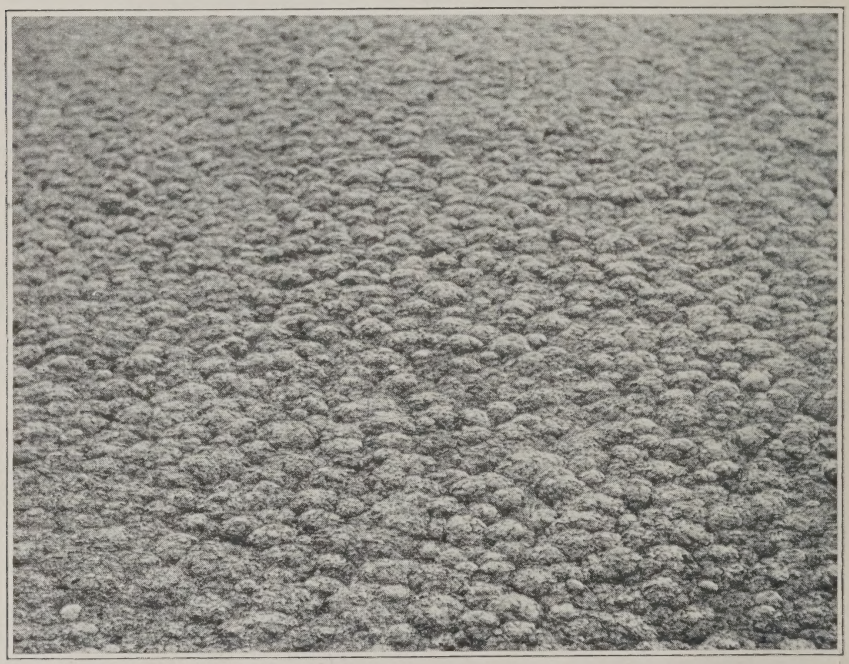
SLUDGE DIGESTION TANK

Fermentation is encouraged by inoculating the weekly supply of sludge from the sedimentation tanks with sludge which is in a state of active fermentation. This is done by drawing ripe sludge from a digestion tank simultaneously with fresh sludge from a sedimentation tank, and pumping

the combination into a digestion tank which has been prepared for it, and invariably contains about 30 per cent. of its capacity of sludge in a high state of putrefaction.

Skill and judgment on the part of the Manager are required in the latter stages in order to secure uniformity of action, and to avoid the creation of nuisance from smell.

The Birmingham experience shows that there is no danger from the smell nuisance, if the work is intelligently and carefully performed.

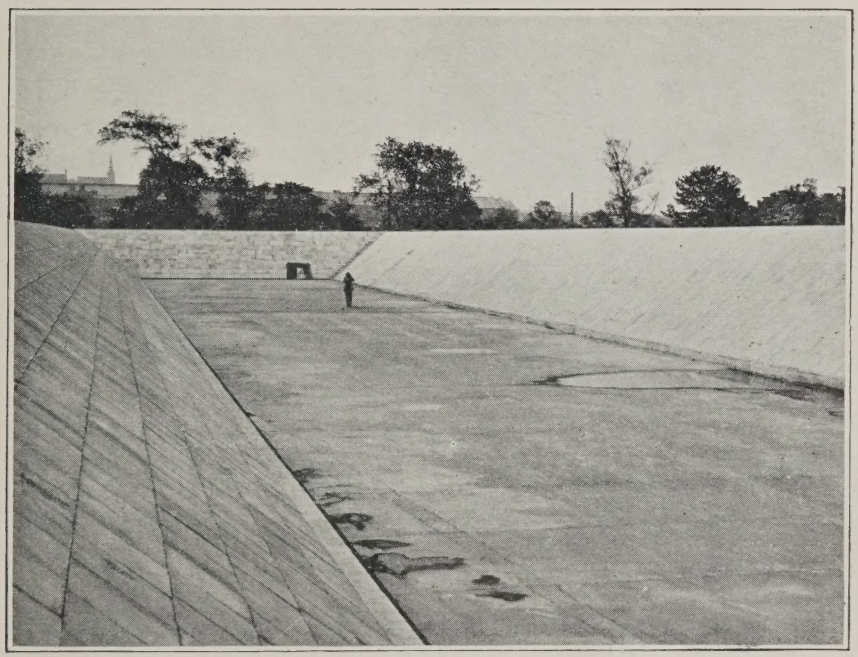


SURFACE OF ACTIVELY FERMENTING SLUDGE

Fermentation is of course more active in the summer than in the winter, but in tanks 12 to 15 feet deep the fermentation process goes on almost without interruption during the average English winter. It is also advisable to retain the surface scum, as it helps to conserve heat, and to some extent may prevent the perception of objectionable smell.

The chief gases emanating from a digestion tank are Methane, Carbon-Dioxide and Nitrogen, and continuous observations go to show that they are in the following proportions : 65-70 per cent. Methane, 27-30 per cent. Carbon-Dioxide, and 4-5 per cent. Nitrogen.

In the course of five months' digestion about one-third of the dry solid matter contained in the sludge is gasified, and what remains is reduced to a condition in which it is readily separated from the water, a condition of great importance where one of the chief items of the process is air-drying.



SLUDGE DIGESTION TANK AT SALTLEY

When the sludge is thoroughly ripe it is pumped through a long sludge main from Saltley to Minworth, where it is poured over the drying beds to a depth of about 18 inches. This depth is generally reduced to about 6 inches as the result of percolation and evaporation. The time it takes to do this

varies with the season and the weather, but the drying beds—about sixty acres in extent—should be filled twice a year.

The beds, which consist of half-acre plots, are underdrained and coated over with a layer of fine ashes, 6in. to 12in. deep, to form a bed for the sludge.

During the lifting season—which usually extends from April to November—much of the sludge is lifted and conveyed to pulverisers, where it is ground up and used as an organic base for a reinforced fertilizer, which is sold with a guarantee of certain analytical standard.

The Board are at present under Contract to dispose of the whole of their dried sludge.

TREATMENT OF SEWAGE

FOR some years prior to 1911 the Sedimentation Tanks at Saltley were used as Septic Tanks with satisfactory results, but in that year it was found impossible to continue this owing to the difficulty of controlling the smell nuisance, because of over-septicisation. It took more than a month to change over from septic tank effluent to sedimentation tank effluent. When this was done it was found to be quite practicable, although difficult, to treat fresh sewage on bacteria beds, notwithstanding the presence of an undue proportion of colloidal matter. This appears to prove what has since been asserted by some observers that bacteria are conservative in their habits, and do not readily apply themselves to unwonted tasks like attacking one kind of sewage to-day and another kind to-morrow.

As the tank effluent leaves Saltley the visible suspended matter amounts to 8 to 10 parts per 100,000, plus the equivalent of approximately 10 parts in a colloidal state.

Between the time of its departure from the sedimentation tanks at Saltley and its arrival at Minworth a certain amount of coagulation takes place in the sewage, and the visible suspended matter is consequently increased, but in addition to this there are at Tyburn and Ashold two intercepting sewers from Sutton and Cole Valley and four from subsidiary districts connected to the main conduit which add more suspended matter to the Saltley tank effluent, so that the sewage as it arrives at Minworth contains from 10 to 12 parts per 100,000, which after passing through the silt tanks is reduced to 8 parts per 100,000.

Anyone visiting the Birmingham Works for the first time is struck by the unusual distance which separates the Sedimentation Tanks at Saltley and the Bacteria Beds at Minworth ($4\frac{1}{2}$ miles), and in looking for the reason he should remember that the present system of treatment succeeded a great irrigation farm and that the Main Conduit had already been laid when the first of the Bacteria Beds was constructed about 20 years ago.

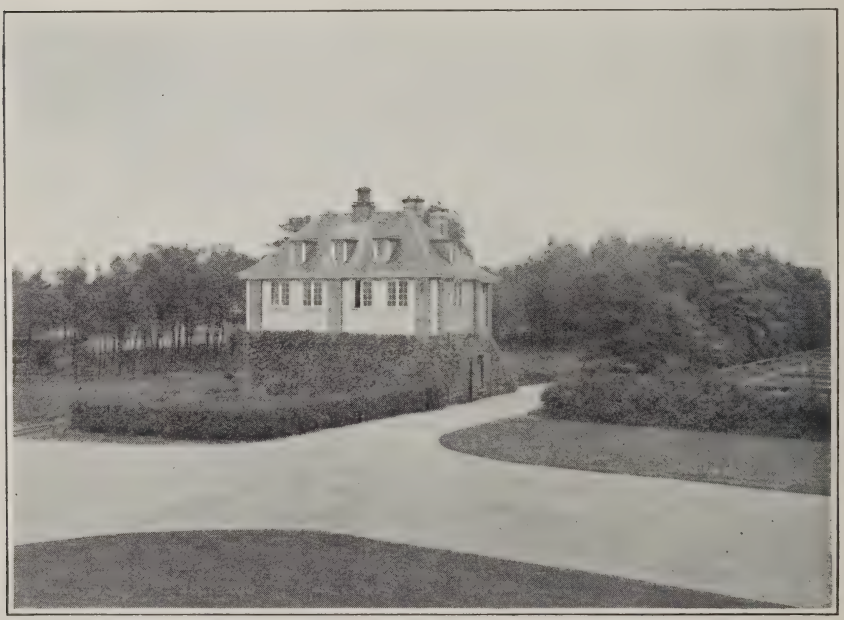
Other reasons for selecting Minworth as the site for the latter were :

(1) The belief generally held in the early part of the century that a 24-hour period of septic action was beneficial, and that the capacity of the existing 8ft. conduit (6,000,000 gallons) would obviate the need for increasing the tank capacity at Saltley.

(2) The fact that the disparity between the falling gradient of the conduit (2 feet per mile) and the river ($7\frac{1}{2}$ feet per mile) provided an available head of 29 feet, with which to spray the sewage over the surface of the bacteria beds.

(3) The available head permitting the construction of silt-tanks at such an elevation as would enable the silt to run by gravitation to suitable land one mile distant.

(4) The isolation of the locality, the unlimited space for extension, and the proximity to canal and railway.

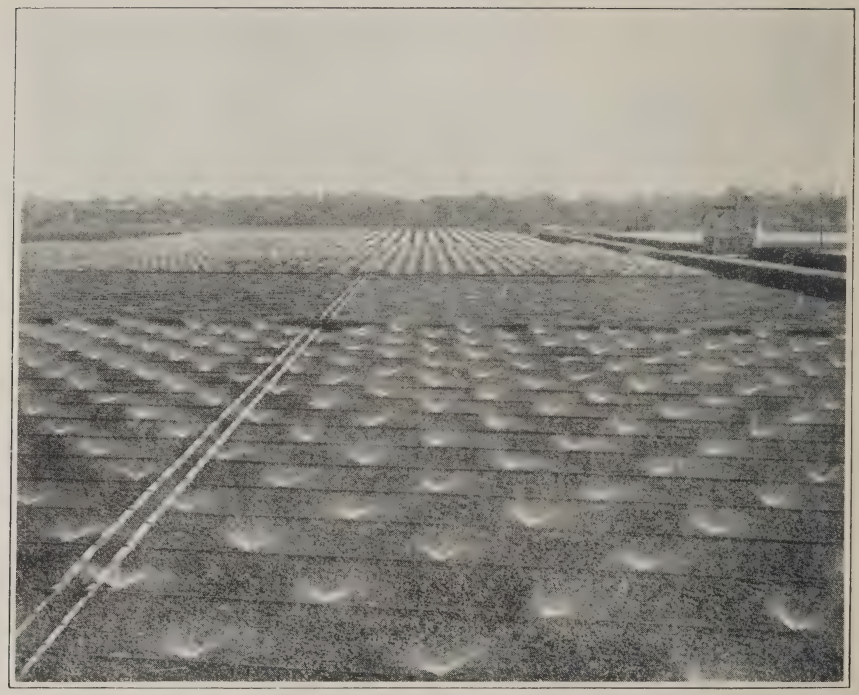


INTAKE AND CONTROL STATION (No. 2) AT MINWORTH

Before the sewage is distributed over the bacteria beds it is made to pass through Silt Tanks, 34 in number.

They differ in form, but generally speaking they form a series of inverted pyramids with vertical walls rising to the surface. Sewage enters by a separate inflow pipe, dipping into the middle of the tank (which is not less than 20 feet deep) the velocity at entry being from one to two feet per second. As it emerges it spreads out laterally at a gradually decreasing velocity until it rises to the square portion of the tank. The normal velocity is 7 feet per hour, but the efficiency is not materially impaired until it exceeds 14 feet per hour.

The great advantage of these tanks interposed between the Sedimentation Tanks and the Bacteria Beds is only partially realised by stating that the cost of the maintenance of the bacteria beds was reduced to one half when the silt tanks were fully operated.



PERCOLATING FILTERS AT MINWORTH

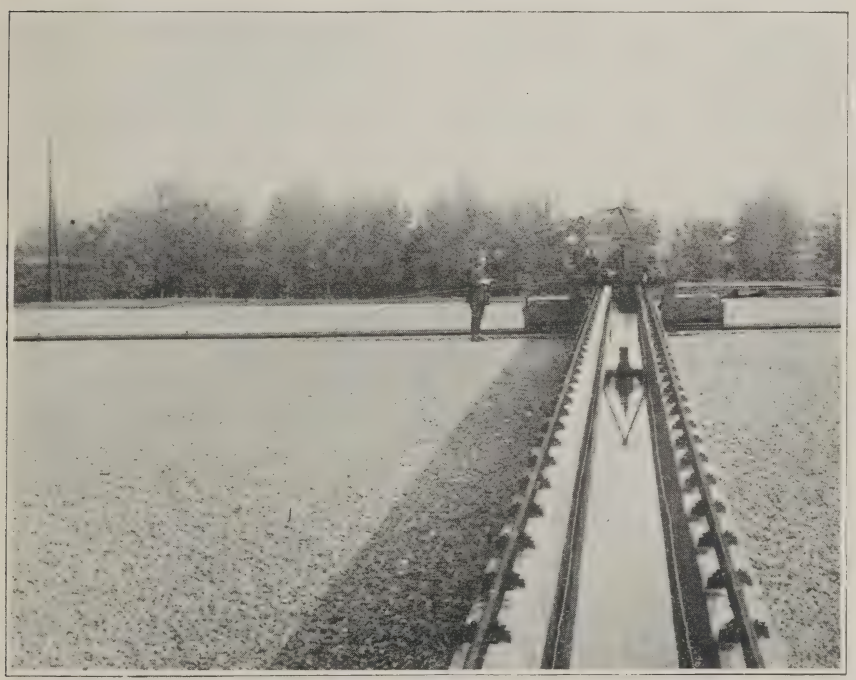
BACTERIA BEDS OR PERCOLATING FILTERS

WHEN the sewage has been prepared as described, it is sprayed over the surface of the filters, which have a total area of 52 acres in the Tame Valley, and with the exception of mechanical distributors on $7\frac{1}{2}$ acres, the whole of the area is served by distributing pipes and fixed spray jets.

The filter is formed on a false floor of aerating tiles, which rests on a bed of cement concrete, and the medium which provides a habitat for the bacteria is composed of hard stone or ball-slag of best quality broken to pass through a 2in. ring and to be rejected by a 1in. ring.

It may be assumed that the smaller the medium used the better will the effluent be. Small medium retains the suspended solids near the surface of the bed for oxidation, but thereby tends to render that surface water-proof, thus losing time available for the purification process so far as the lower portions of the bed are concerned, and consequently increasing the cost per millon gallons treated.

The stone and slag media by retaining their form permanently have a great advantage over media which tends to break down, but the economical side of the question must not be lost sight of in determining the character of medium to be employed, as both kinds are equally effective whilst in good condition. The large medium obviates clogging, but it necessitates the use of Humus Tanks.



MECHANICAL SEWAGE DISTRIBUTOR

The Humus Tank is in all respects similar in construction to the Silt Tank. It arrests a large proportion of the humus in the filtrate, and it does so at a small cost (about 4/- per million gallons), but having eliminated the humus the difficult task of disposing of it is presented. After many experiments it is now pumped back to the Sludge Digestion Tanks, and mixed with ordinary sedimented sludge.

BALANCING TANK, SALTLEY

STORM WATER

ONE of the findings of the Royal Commission was that sewage exceeding in volume three times the dry weather flow should be treated as Storm Water, and in order to give Storm Water time to part with its solids they recommended that a tank, or tanks, should be provided sufficient in capacity to store one quarter of the daily dry weather flow.

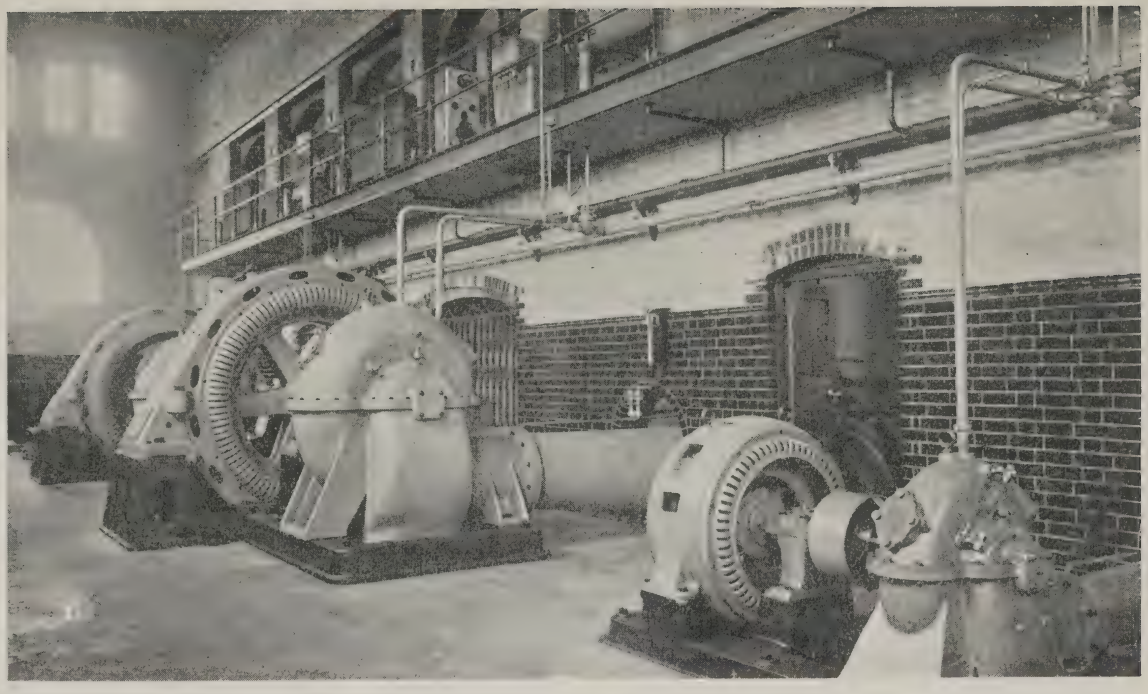
When this recommendation was made the Drainage Board had already provided about 30 acres of Storm Water filters, but they recognised the wisdom of the recommendation, and without delay proceeded to build Settling Tanks in conjunction with a Balancing Tank. Without reckoning the capacity of the Balancing Tank there is storage capacity sufficient to meet the requirements of the Ministry of Health, and with it the tanks are capable of impounding 13 million gallons, or about one half of the dry weather flow.

The normal condition of the river alters quickly after rain. The great area of paved surfaces puts a severe strain on the sewers, and Storm Water overflows come into operation even before the river is swollen by land drainage. The Drainage Board (aware of the difficulties of its Constituent Authorities) have anticipated suggestions to provide more accommodation for Storm Water by voluntarily extending their Storm Water Tanks, and at this time (July, 1923) a Tank capable of impounding 6,500,000 gallons is being added to the installation.

The Birmingham Storm Water Filters were constructed under pressure of the Court. They are not so efficacious as Settling Tanks and they are more costly, but they have the merit of being able to relieve the pressure on the ordinary bacteria beds at a time when the latter are under great strain. They are formed of Gas Works' ashes built up in the form of two great Percolating Filters, separated from each other by a long effluent channel into which they both drain. The sewage gravitates from the Balancing Tank to a well at the back of the Pumping Station, where it is pumped by Centrifugal Pumps, electrically driven, into the system of distribution pipes which feed fixed spray jets similar to those on the Minworth bacteria beds. The floors of the Filters are laid at a level which is just above the reach of the ordinary floods (289 feet above O.D.) so that all the Storm Water has to be pumped high enough to produce sufficient head to secure efficient distribution.

Notwithstanding their distinct preference for medium of substantial and permanent character the Board did not feel warranted in overlooking the great difference in the cost of ashes as compared with stone and slag—only one sixth—and they resolved to accept the offer of the Corporation Gas Department to lay down, free of cost, their waste ashes on the site ; these were washed, screened, and laid into the bed for 1/- per cubic yard.

This Storm Water Filter was built with money partially obtained from Revenue, but mainly from money obtained on a short period loan.



INTERIOR OF STORM WATER PUMPING STATION AND HIGH TENSION TRANSFORMING STATION

GENERAL VIEW OF SEDIMENTATION AND

LUDGE DIGESTION TANKS AT SALTLEY.

RECENT DEVELOPMENTS

In view of the fact that the Drainage Board's district increases year by year, and that it is necessary to build an acre of bacteria beds per annum to keep pace with the increasing volume of sewage, the Board deemed it necessary to put down an Activated Sludge, or Bio-Aeration Experimental Station. The Ministry of Health proposed at one time to defray the expense of the Birmingham experiments, but the Treasury refused their consent. The Board, therefore, employed their own Chemist to experiment on lines which were assumed to be the best for the solution of Birmingham problems.

Three plants, each capable of dealing with 10,000 gallons of sewage per day, were constructed : (1) Activated sludge, by air-blowing, advocated by the Manchester school ; (2) Bio-aeration, by agitation, advocated by the Sheffield school; and (3) Percolating filters, composed of gravel, built on generally approved methods. The latter were sub-divided into three sections of different depth, each possessing the same cubic capacity. These experiments have been in the charge of the Board's Chemist and they have led to the establishment of the following important facts :

(1) That the Birmingham sewage is amenable to treatment either by the air-blowing, or the agitation method.

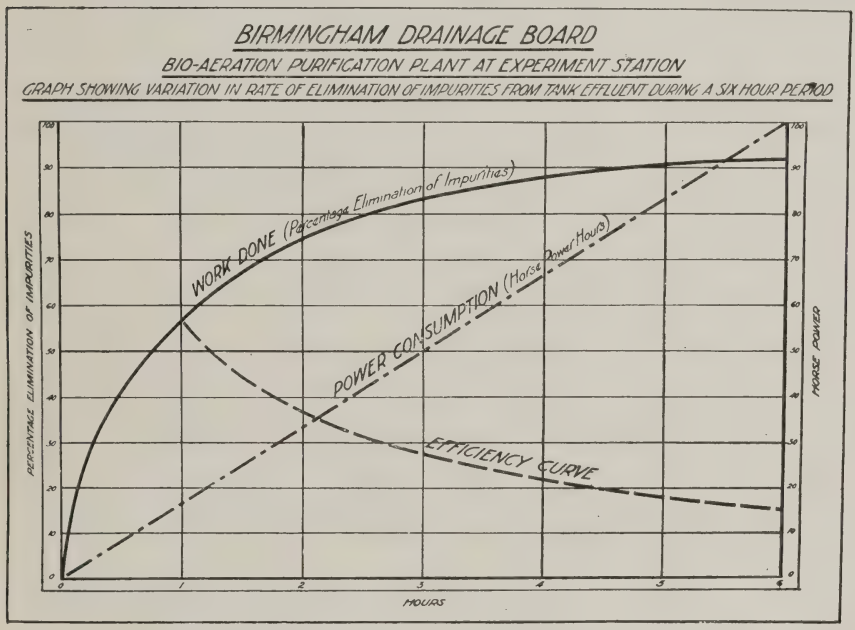
(2) That a tank liquor forms a better subject for purification than crude sewage.

(3) That efficient flocculation of tank liquor for one hour removes 60 per cent. of its impurity.

(4) That flocculation of tank liquor for one hour removes all objectionable smell.

(5) That flocculation of tank liquor for one hour produces a liquor which may be oxidised at more than double the present rate on a percolating filter.

Each one of these points is of great importance. The first may be of purely local value, but seeing that the Birmingham sewage absorbs 26 parts of oxygen per 100,000 as against 10 or 12 parts per 100,000 at Manchester, and rather less at Sheffield, it is of more than local importance to prove that a sewage containing trades' waste, which absorbs so much oxygen is amenable to Activated Sludge, or Bio-Aeration treatment.

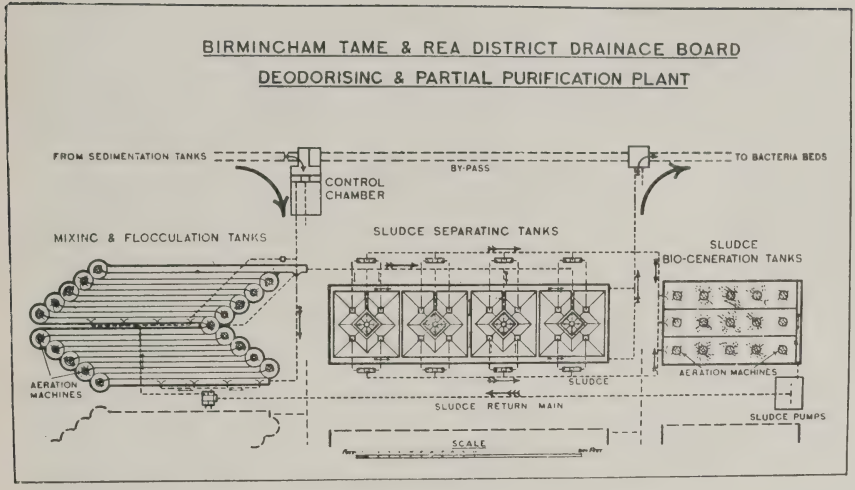

BIRMINGHAM DRAINAGE BOARD
BIO-AERATION PURIFICATION PLANT AT EXPERIMENT STATION
GRAPH SHOWING VARIATION IN RATE OF ELIMINATION OF IMPURITIES FROM TANK EFFLUENT DURING A SIX HOUR PERIOD
WORK DONE (Percentage Elimination of Impurities)
POWER CONSUMPTION (Horse Power Hours)
EFFICIENCY CURVE
PERCENTAGE ELIMINATION OF IMPURITIES
HORSE POWER
HOURS

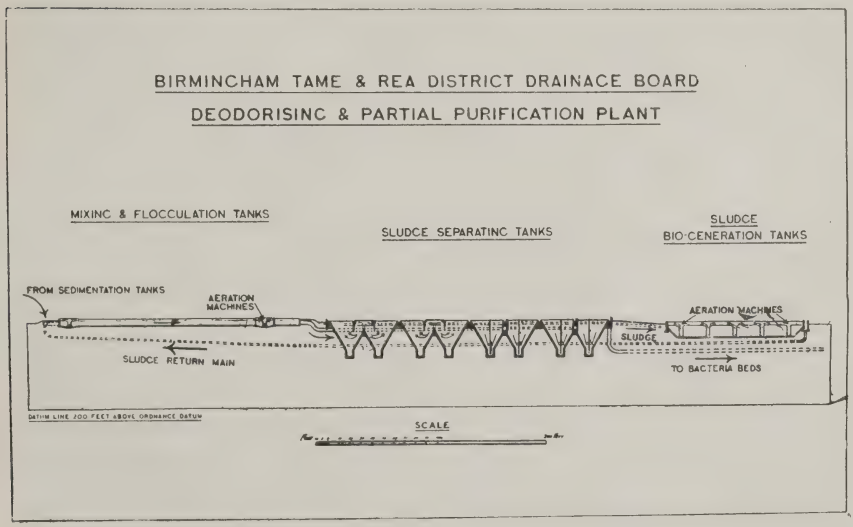
It is impossible, in the Birmingham district, to boat sludge out to sea, as in London, Glasgow, and Manchester, but it is dealt with quite as effectively by a process of digestion which renders it odourless, frees it from grease, conserves its nitrogen and still leaves it available to the farmer. Further, there is no object in carrying forward more sludge to the Bio-Aeration plant than is absolutely essential to provide the medium or nidus on which healthy organisms are cultivated and the Birmingham experiments show that 8 parts per 100,000 of suspended visible solids, plus 10 parts of colloidal sludge, are sufficient for this purpose.

The removal of 60 per cent. of the impurities in the sewage in the first hour of the aeration process is of great moment. The removal of colloidal matter to a large extent and the riddance within an hour of smell are matters for congratulation, and the Board is also attracted by the benefits specified under (5) when it is shown that flocculated sewage, which has been deprived of colloidal matter, is much more readily oxidised, and consequently existing bacteria beds will be rendered capable of treating efficiently considerably more than double the volume of sewage hitherto applied to them. The bacteria beds will thus be relieved of work for which they are not well fitted. They are no doubt capable of dealing with humus which arises from the particulation of colloidal matter, provided sufficient time and favourable conditions are given, but it is not profitable to keep them employed on work for which they are not well fitted.

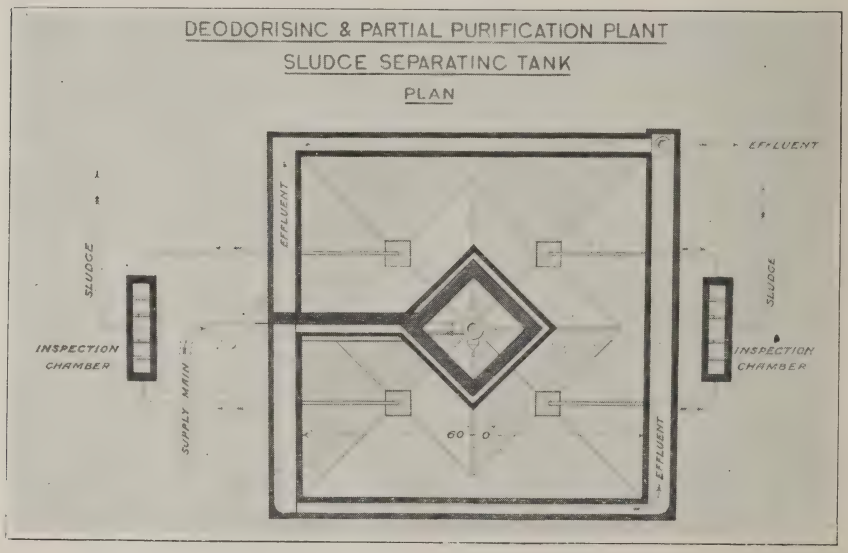
These facts have influenced the Board in bringing forward a Scheme which will at once get rid of smell and increase the purifying capacity of the percolating filters. Although the Board have given consent to construct only about one-third of the work illustrated it will prove, quite apart from establishing the facts already indicated, an auxiliary to the Board's Sewage Purification Works. It will take up the peak of the load, and will eliminate the troubles on the surfaces of the filters due to matter which retards the oxidising of the impurities in solution.

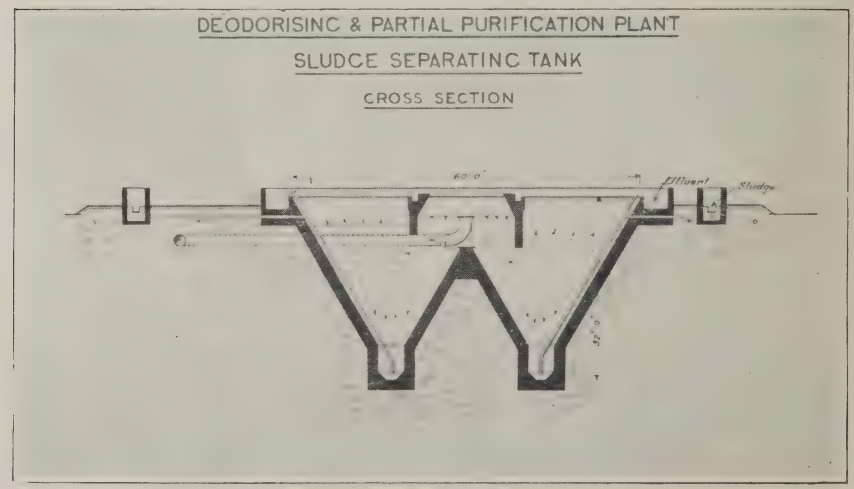
The installation as it was first proposed showed the process divided into three sections—flocculation, settlement, and re-aeration. The flocculating channels are 4ft. 8in. wide, and 4ft. 4in. deep, constructed on a gradient that will produce a velocity of 1ft. per second and arranged so that the sewage will be in the channels for exactly one hour, when it will be conveyed to the separating tanks which are designed to remove the exhausted sludge. This sludge will then be conveyed to the re-aeration or bio-generation chamber, where atmospheric air, as the result of mechanical agitation, will be mingled with it, until it is revivified and made ready to act upon the incoming sewage in its passage from the flocculating channels, to which it will be pumped by means of electrically operated pumps.

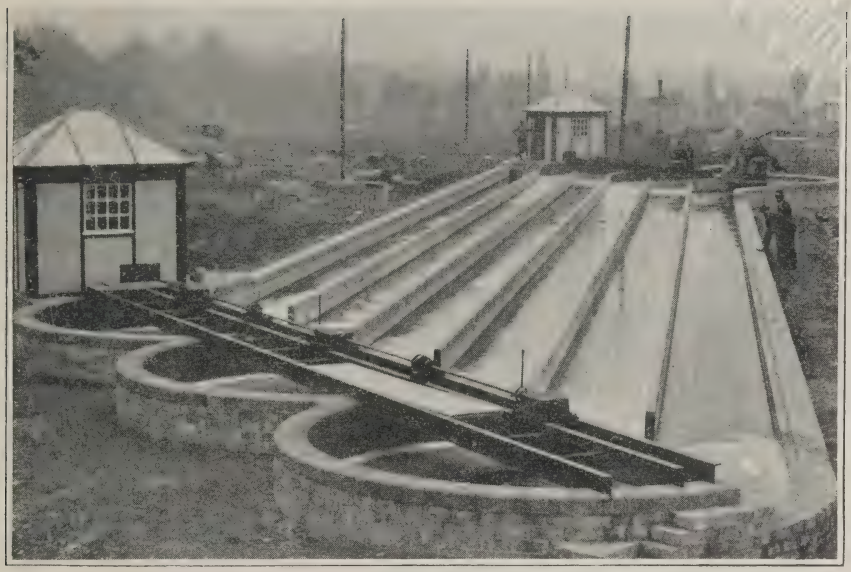

BIRMINCHAM TAME & REA DISTRICT DRAINACE BOARD
DEODORISINC & PARTIAL PURIFICATION PLANT
FROM SEDIMENTATION TANKS
CONTROL CHAMBER
BY-PASS
TO BACTERIA BEDS
MIXINC & FLOCCULATION TANKS
SLUDCE SEPARATINC TANKS
SLUDCE BIO-CENERATION TANKS
AERATION MACHINES
SLUDCE
AERATION MACHINES
SLUDCE RETURN MAIN
SLUDCE PUMPS
SCALE


BIRMINCHAM TAME & REA DISTRICT DRAINACE BOARD
DEODORISINC & PARTIAL PURIFICATION PLANT
MIXINC & FLOCCULATION TANKS
SLUDCE SEPARATINC TANKS
SLUDCE BIO-CENERATION TANKS
FROM SEDIMENTATION TANKS
AERATION MACHINES
AERATION MACHINES
SLUDCE
SLUDCE RETURN MAIN
TO BACTERIA BEDS
DATUM LINE 200 FEET ABOVE ORDNANCE DATUM
SCALE

It is too early to speak with absolute certainty of what this plant can do, but if the work carried out at the Experimental Station is to be relied upon this larger experiment should prove the wisdom of interposing this deodorising and partial purification plant between the sedimentation tanks at Saltley and the oxidising or bacteria beds at Minworth.







BIO-FLOCCULATION TANK

SLUDGE RE-AERATION TANK

COLE VALLEY WORKS

The two Sewage Purification Works in the Cole Valley are situated at Colehall and at Acocks Green.

COLEHALL.

The Colehall plant deals with a population estimated at 100,000, and the dry weather flow of sewage at the present time is about 2,750,000 gallons per 24 hours.

The plant consists of six detritus tanks, which have a total capacity of 100,000 gallons ; nine settling tanks, which have a total capacity of 2,000,000 gallons, and three storm water tanks, which have a total capacity of 1,500,000 gallons.

The bacteria beds consist of 19 rectangular beds, $5\frac{1}{2}$ acres in area, and 4 circular beds, with an aggregate area of half an acre. There are also two humus tanks possessing a total capacity of 500,000 gallons.

The land set aside for the disposal of sludge has an area equal to 10 acres, and one of the features of the installation is to pump back to the detritus tanks the drainings from this sludge. By this means the sludge water is made to mix with the incoming sewage.

28 ENGINE HOUSE AND PUMPING STATION AT COLEHALL

In the main the Works follow the characteristics of the main plant already described, but the sewage is more of a domestic character and, judged by the Ministry of Health standard, it is a strong sewage as the following table indicates :

Oxygen absorbed in 4 hours	..	13·11	parts per 100,000
Free and Saline Ammonia	..	3·66	,, ,,
Albuminoid Ammonia	..	1·27	,, ,,
Chlorine	..	9·50	,, ,,
Total Suspended Matter	..	40·00	,, ,,

The River Cole, into which the effluent is discharged, is still called by riparian owners a fishing stream, but whether that is a correct definition or not, the fact remains that it is a much purer stream than the River Tame, and in consequence great care is taken to produce an effluent of a higher standard. This has occasioned the construction of a larger area of bacteria beds in proportion to the volume treated than have been constructed at Minworth. More pains are also taken to free the filtrate from suspended matter, as it is made to flow through beds of water grass before it enters the stream.

ACOCKS GREEN

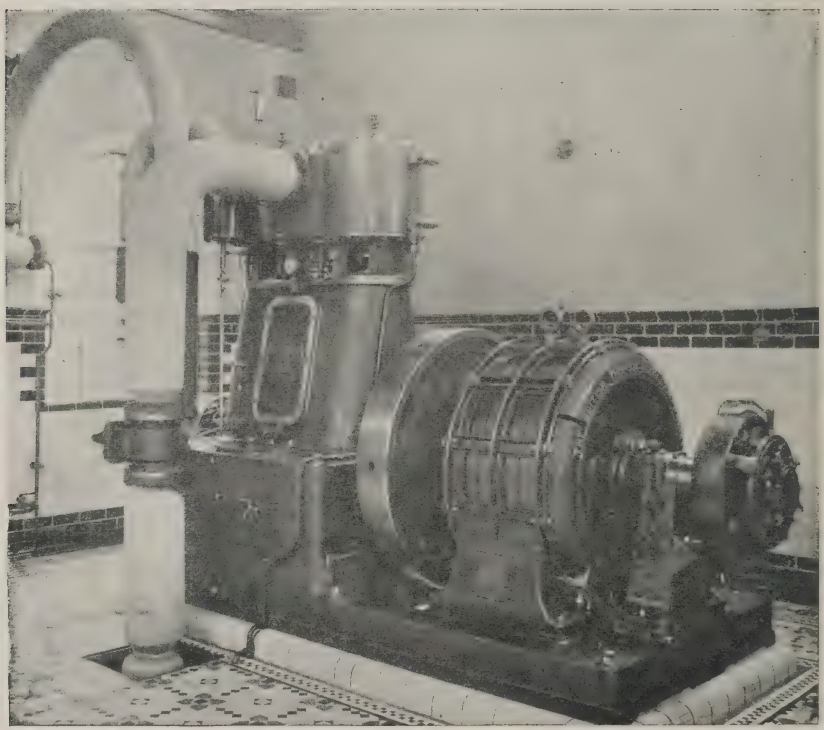
The population served by the Acocks Green installation is about 10,000, and the dry weather flow about 250,000 gallons per day.

There is a marked difference between this installation and the others in respect of the medium used in the bacteria bed. Here a level piece of ground is drained by means of ordinary land tiles laid about 6ft. apart, over which ashes have been dumped with very little regard to size. The bed is one acre in area, and has an average depth of 7ft. The sewage is distributed over the surface of the filter by means of iron pipes placed about 6ft. apart. The liquid emerges from open orifices placed at 3ft. intervals along the pipe. The whole work has been done on the assumption that it will not require to last for more than 10 or 15 years, as it is anticipated that within that time it will be necessary to construct a sewer between Acocks Green and Colehall.

At these Works 2½ acres of land have been set aside for sludge disposal and 15½ acres have been set aside and are being used for storm water, but a storm water tank, having a capacity of 130,000 gallons, is in course of construction.

THE ELECTRICAL BRANCH OF THE UNDERTAKING

IN 1903 the Board resolved to substitute some form of electrical drive for the isolated steam pumping plants situated at various parts of the Works, and an arrangement was subsequently come to with the Corporation of Birmingham by which surplus steam from their Nechells Destructor was made available to generate electrical energy in the Generating Station which was erected in 1905.

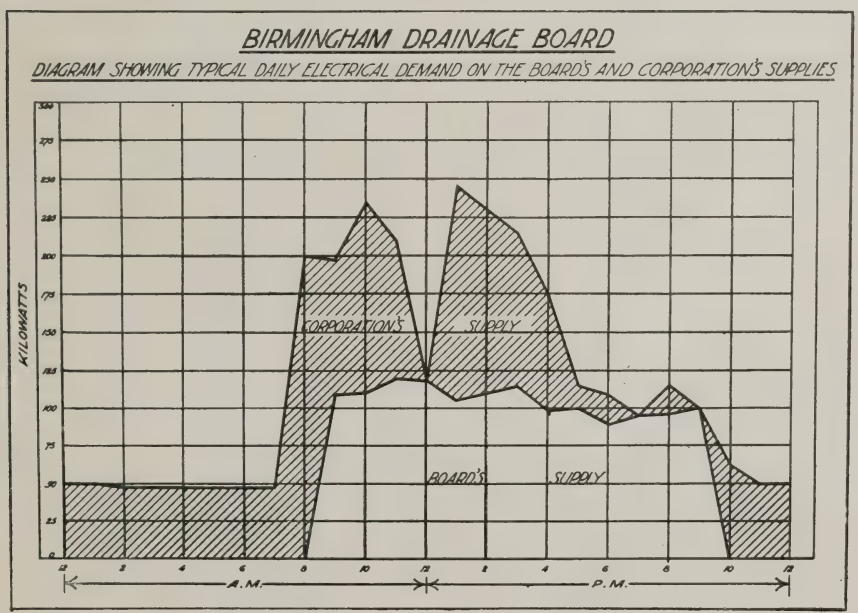


The Generating Station equipment consists of two 115 K.W. British Thomson-Houston generators, each coupled to a Bellis & Morcom 175 B.H.P. high-speed engine running at 428 revs. a minute. The generators supply a three phase alternating current, 50 cycles, at a pressure of 2,300 volts,

through the necessary switchgear to an overhead transmission line extending throughout the Board's Works. The overhead line consists of hard-drawn solid copper conductors supported on triple-shed porcelain insulators attached to creosoted wood poles, the span varying from 40 to 50 yards. At all public road crossings, on land that has passed out of the hands of the Board, and where buildings have been erected, the transmission is by underground cables.

The general plan adopted has been to put down sub-stations wherever a supply of electric power is needed, there the pressure is transformed to 220 volts for local lighting and power requirements.

When the electric power was first adopted it was hardly realised that it would become so essential to the Board's work, and the rapid growth of this side of the work is illustrated by comparing the power required in 1905 with what is needed to-day. The figures are: 140 H.P. in 1905, and 1,280 H.P. in 1923. It soon became evident that the power generated from refuse destructor steam was not sufficient for the work of the Board, and an arrangement was come to with the



Aston Town Council to supply the balance. Aston was preferred to Birmingham because their frequency coincided with our own, viz., 50 periods, whereas the Birmingham frequency was 25 periods.

The supply from the Public mains is brought into the Storm Water Pumping Station at a pressure of 6,000 volts, and it is then transformed to a pressure of 2,300 volts to enable it to be run in parallel with the Board's own Generating Station. By this means the demand over and above what can be generated by the Board's Station is taken from the Public Supply.

The Storm Water Pumping Plant consists of two Centrifugal Pumps directly coupled to electric motors of 55 B.H.P. and wound for 2,200 volts, and two of 225 B.H.P. wound for 6,000 volts.

During the War the Board were asked to give a supply of electric power to the Aerodrome at Castle Bromwich. To do this without detriment to the Board's undertaking the pressure on the overhead transmission line was increased from 2,300 to 4,000 volts. This was done by means of transformers installed in the Storm Water Pumping Station, and by altering the connections of the step down transformers in the various sub-stations the whole of the existing gear was retained in use.

In addition to the large pumps mentioned above there are :

7 motors for pumping sewage of an aggregate H.P. of	140
8 motors for pumping sludge of an aggregate H.P. of	166
10 motors for washing sand and ashes and stone-breaking of an aggregate H.P. of ..	158
7 motors for workshop purposes of an aggregate H.P. of	60½
5 motors for screens, elevators, etc., of an aggregate H.P. of	12½
1 motor for travelling dredger of a H.P. of ..	15
3 motors for air compressors of an aggregate H.P. of	38
18 motors for operating sluice valves of an aggregate H.P. of	9

4 motors for Bio-Aeration plant of an aggregate H.P. of 32
1 motor for battery charging plant of a H.P. of 22
1 motor for overhead travelling crane of a H.P. of 30

The foregoing list indicates only some of the various uses to which electricity may be put on a modern sewage works.

Another interesting feature of the Electrical Undertaking is a fleet of four electric battery locomotives. These are used in the sludge drying area for hauling wagons from the drying beds to the tip. Owing to their comparatively light weight and ease of operation they can run on temporary tracks which would be impossible for heavier machines. These locos are capable of hauling 10 tons on the flat, being equipped with a motor rated at 1 H.P. with an overload capacity of 300 per cent. for a few minutes. Three of the locos are equipped with Nickel Iron cells and one with a Lead battery. It should be stated, however, that the Electric Battery Loco is not ideal for speed or steep gradients.

To enable the whole of the Board's Works to be run in harmony, especially in times of storm, each part and section of the Works is linked up by a Private Telephone System, the exchange being situated in the Storm Water Pumping Station, where a Shift Engineer is always on duty.

WORKSHOPS AT MINWORTH

THE MECHANICAL EQUIPMENT OF THE UNDERTAKING

THE development in methods of sewage purification during the last 20 years has given an impetus to the use of mechanical equipment.

The diversity of purposes for which machines are used is most marked, and covers a range of operations too extensive to be more than briefly referred to.

The largest branch, and one replete with interesting and difficult problems is that relating to Sewage Sludge pumping.

The amount of crude sludge removed from the Sedimentation Tanks at Saltley amounts to 400,000 cubic yards per annum, and as this volume during its treatment requires to be pumped at least three times it is in itself a work of some magnitude. The types of pumps in use are direct acting, duplex steam driven pumps, and electrically driven treble ram pumps, working at a slow piston speed of about 50 feet per minute.

Both types of pumps give good results when dealing with sludge containing 90 per cent. water.

An interesting feature in connection with Sludge pumping is the fact that one of the sludge pumping mains is 21,000 feet in length and that the " head " to be overcome is entirely due to friction there being no difference between inlet and outlet to create a static head.

The crude sludge is screened before pumping by three electrically operated " Stott " screening machines. Sludge containing over 95 per cent. water (principally from the Silt and Separating Tanks at Minworth) is usually pumped by some form of centrifugal pump (e.g., " Stereophagus " or " Unchokeable " pumps for sizes of 6in. or under and ordinary types of centrifugal pumps when the required size is over 6in.).

Wherever possible detritus is mechanically removed before the sewage is allowed to pass into the Sedimentation Tanks. Fixed electrically operated bucket elevators are employed at the Sutton and Ashold Works, and a large travelling machine, also electrically operated, removes approximately 240 cubic yards from the incoming sewage at Saltley daily.

The Birmingham Works being almost entirely " gravitation " Works do not necessitate a large amount of pumping other than sludge pumping, but a low lift pumping installation at Saltley, erected in 1908, for dealing with Storm Water, and now used in conjunction with a balancing tank to equalize the rate of treatment when the rate of flow approaches three times the rate of dry weather flow, is worthy of notice. This installation comprises four " Allen " centrifugal pumps of a total capacity equal to 72,000,000 gallons per 24 hours.

The Cole Hall Works are situated two miles from the

nearest Railway Station and almost the same distance from gas or electricity mains.

In view of these facts, when it became necessary to provide some form of power for the purpose of sludge pumping, it was deemed a favourable opportunity to install an experimental gas plant to produce Methane (CH_4) by fermentation of Sewage Sludge and use the gas to drive a 32 H.P. horizontal gas engine.

The plant has been in operation since September, 1921, and although the rate of gas generation has fallen short of expectations, especially during the winter months, the experiment has clearly shown that it is, under favourable conditions, a practicable means of power supply.

The Board operate a small Sewage Pumping Station in the Bromford district by means of Shones Ejectors supplied with compressed air from the Saltley Sludge Pumping Station. The quantity of sewage lifted from this Station is approximately 80,000 gallons per day.

The new deodorising and partial purification plant at Minworth promises to be an important part of future mechanical equipment, and affords possibilities for the employment of novel applications of power to produce conditions necessary for biological flocculation of sewage. The section of plant now being brought into operation is provided with 10 " Simplex " Aeration Machines, a low lift " Fen " pump for circulation purposes and two " Duplex " ram pumps for sludge circulation.

The whole of this plant is driven by three-speed electric motors.

The demand for economical transport and handling facilities affords scope for the employment of a considerable amount of plant, and in this respect the Tame Valley Works are well placed with regard to Railway and Canal connections. A system of 2ft. gauge railway of a total length of 14 miles single track connects most parts of the Minworth Works with the Board's Wharf on the Birmingham and Fazeley Canal, and a Private Siding on the London, Midland and Scottish Railway at Water Orton.

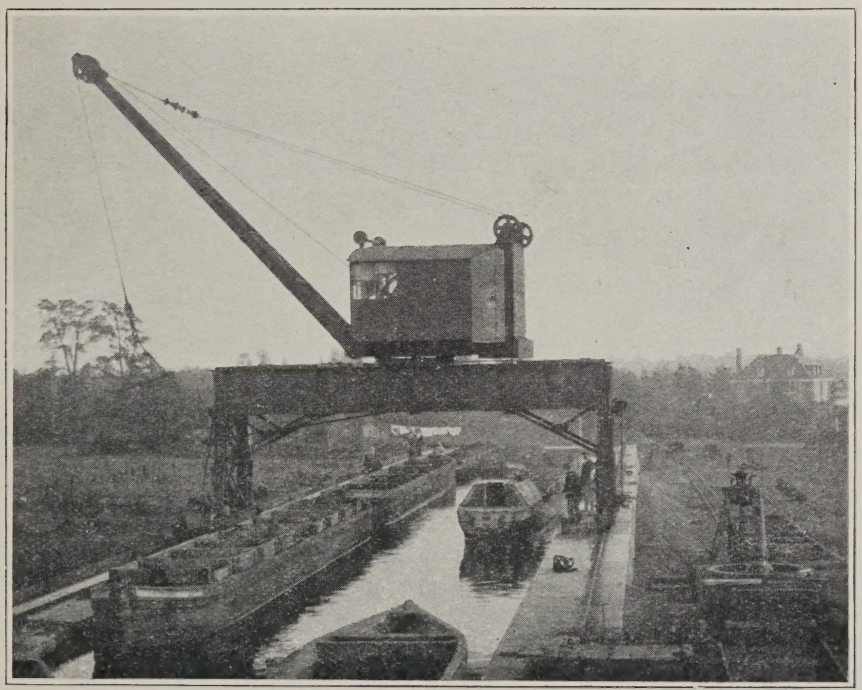
The Saltley Works are similarly connected to a Railway Siding and Canal Basin.

The following rolling stock is employed :

2 Standard Gauge Steam Shunting Locomotives.
4 2ft. Gauge Steam Locomotives.
3 „ „ Petrol „
4 „ „ Electric Battery Locomotives.
450 1 yard Tip Wagons.
60 4 „ Box „

Four Steam Locomotive Cranes from 5 tons to 30 cwts. capacity, and one 5 ton Electric Crane are in use at various points for loading and unloading purposes.

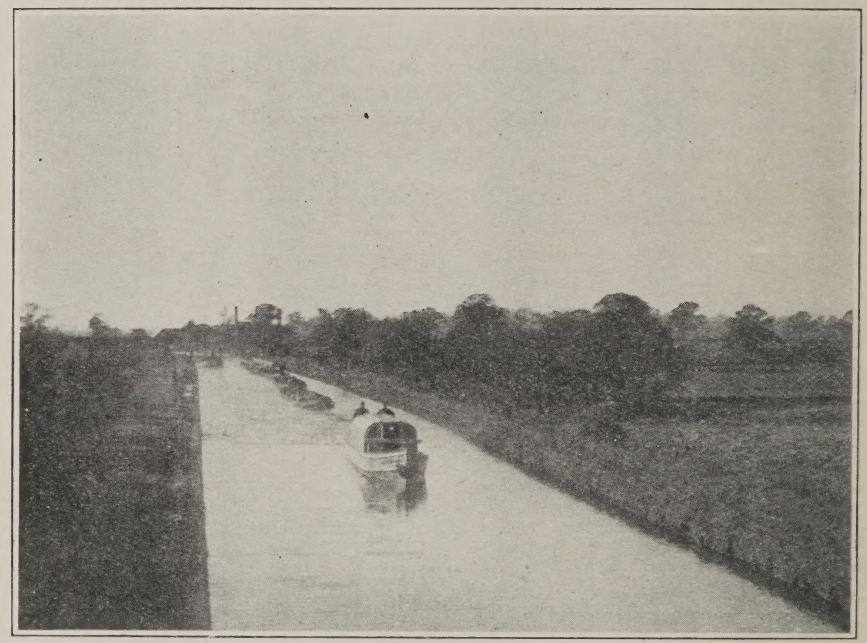
Canal transport is employed to a considerable extent in conveying materials to and from the Minworth and Saltley Works. The principal class of material so transported is Ashes from the Birmingham Corporation Gas and Electricity Works, which, under agreement with the Corporation, the Drainage Board collect at the several Works and convey to Minworth for use on the Sludge Drying Area, Railways, Roadways, etc.



MINWORTH CANAL BASIN

For the speedy and convenient handling of these ashes the canal boats employed are each fitted with eight box containers. On arrival at the Board's Wharf the box containers are transferred by means of a 5 ton Electric Crane to eight 2ft. gauge bogies, which are hauled to a screening plant into which the ashes are tipped by another 5 ton Crane.

The canal haulage is performed by horses in the upper and lower lengths of the canal where locks are numerous, and by motor tug and motor barge in the middle length where a level run of nearly three miles is practicable.



MOTOR TUG AND FIRE BOX BARGES

The cost of this transport scheme is borne by the Birmingham Corporation, the constructional work and administration being carried out by the Board, who allow the value of the ashes in part rebate of working expenses.

The Board have, for many years, used the deposits of sand and gravel found on their lands at Minworth for constructional purposes, and to provide a medium for Bacteria Beds.

In connection with this work the following washing, grading and crushing plants have been installed:

Two washing and screening plants of a combined capacity of 25 cubic yards per hour, and two crushing and screening machines together equal to an output of 20 cubic yards per hour.

The bulk of sewage distribution on the Bacteria Beds is carried out by means of fixed spray distributors, but there are 11 " Barkers Mill " revolving distributors working on some of the older Bacteria Beds, and 39 travelling " Ames Crosta " distributors working over an area of 12½ acres.

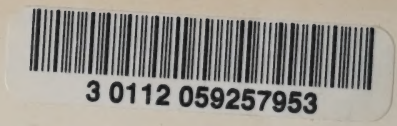
Both types of machines obtain their motive power from the head of sewage which supplies them.

Gauging and Recording instruments are too numerous to mention individually, but the most usual type used for measuring the flow of large volumes of Sewage is the " Lea " recording and integrating machine.

The maintenance of machinery and plant which is of necessity in many instances required to work continuously demands ample facilities for speedy repair or renewal, and the following list of machine tools installed at the Minworth and Saltley Workshops will give some indication of the means which have been found necessary to maintain an efficient service.

6 Blacksmith's Hearths, with Electrically operated Draught.
4 S. S. & S. Lathes, 12in. to 6½in. height of centres, and 12ft. to 3ft. between centres.
1 36in. Radial Drill.
1 Pillar Drill.
3 Sensitive Drills.
3 Portable Electric Drills.
1 Shaping Machine, 18in. stroke.
1 Portable Acetylene Welding and Cutting Apparatus.
2 Brass Melting Furnaces for small castings.

A Saw Mill, equipped with a 72in. rack saw, two circular saw benches, and a band saw is an extremely useful part of the workshop.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Miscellaneous items of plant form a considerable portio of the equipment of a large Works, and the following incom plete list is some indication of the diverse nature of thi portion of the Mechanical equipment :

10 Ton Steam Road Roller.
Tar Spraying Machine.
Portable and Semi-portable Concrete Mixers.
Portable Steam Engines and Pumps.
Hand Winches and Derrick Cranes.
Portable Electric and Petrol Engine Pumps.
3 Ton Petrol Wagon.
Ford Van.
Staff Cars.
Petrol and Horse drawn Mowing Machines.
Portable Gravel and Sand Washing Machine.